DETECTION OF OFF-NORMAL IMAGES FOR NIF AUTOMATIC ALIGNMENT

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Automatic Alignment & Imaging Team
Integrated Computer Controls System
National Ignition Facility (NIF)
Lawrence Livermore National Laboratory

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Organization

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- Background
- Problem Definition
- OFF-NORMAL Pre-Processing
- Processor Design
- Case Study: Back-lit Corner Cube Reflector
- Results
- Summary

NIF Auto Alignment Map

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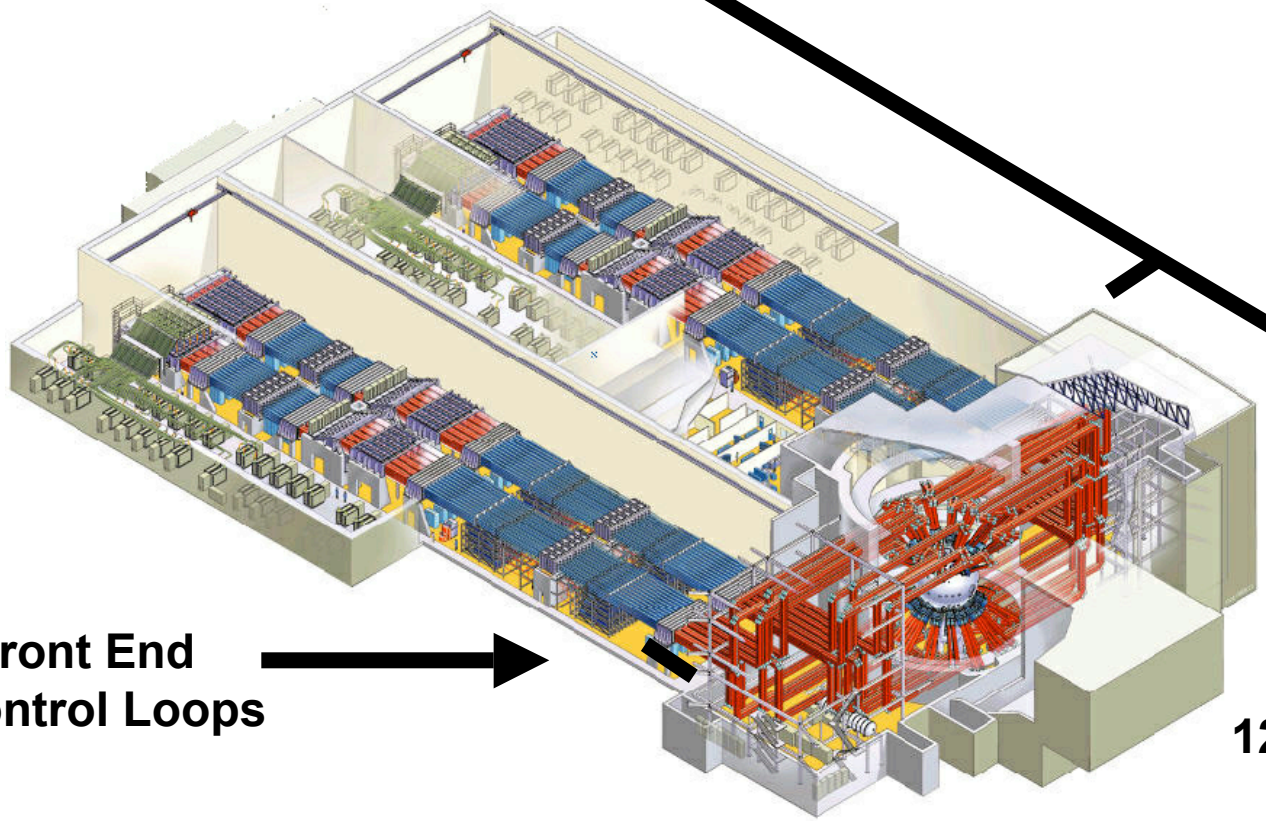

Main Laser
11 Control Loops

Switchyard & Target
Area
17 Control Loops

Front End
7 Control Loops

NIF Total
2300 Control Loops
12000 Actuated Devices
330 Cameras

Beam Control & Automatic Alignment tasks include

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Processing alignment video image data, extracting current reference/beam positions and centering the beam for the upcoming laser shot

Imaging group must:

- **Process "noisy," sometimes distorted, images**
- **Extract the current positions of reference and beam**
- **Develop algorithms to produce timely and precise position estimates**
- **Thoroughly test and analyze performance of algorithms**
- **Deliver algorithms to the experiment for immediate application**
- **Maintain and alter imaging algorithms as the beamlines change**

Principle of Pointing Optics

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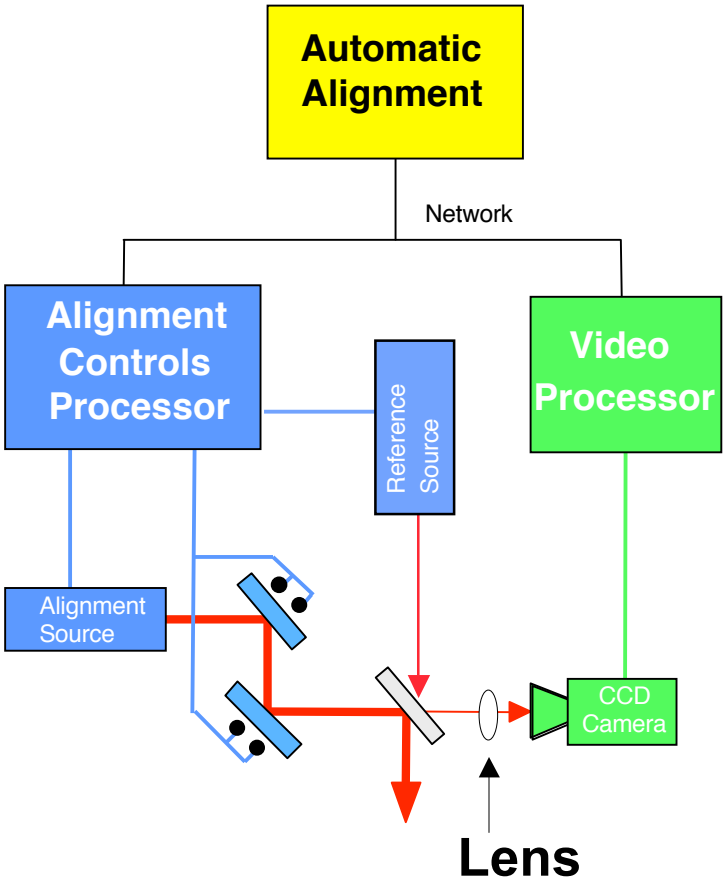

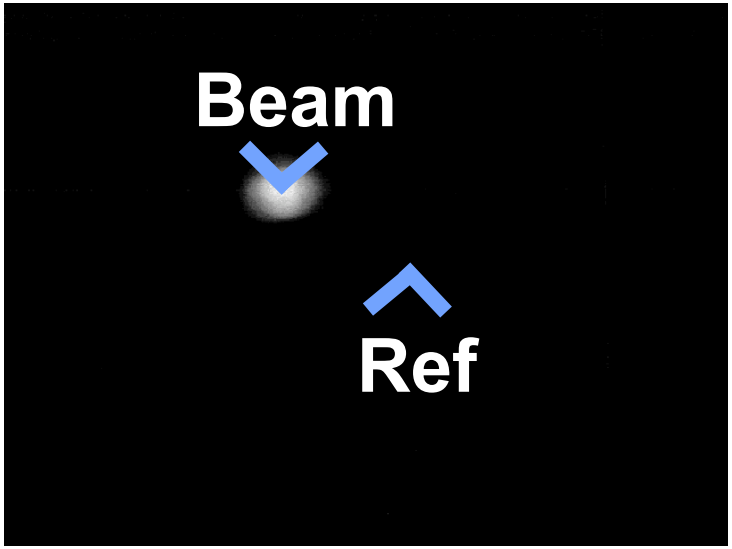

CCD Image

The Beam Alignment Source is aligned to a separately processed Reference Source

Imaging anomalies can occur when equipment malfunctions --- like a “sticky” shutter

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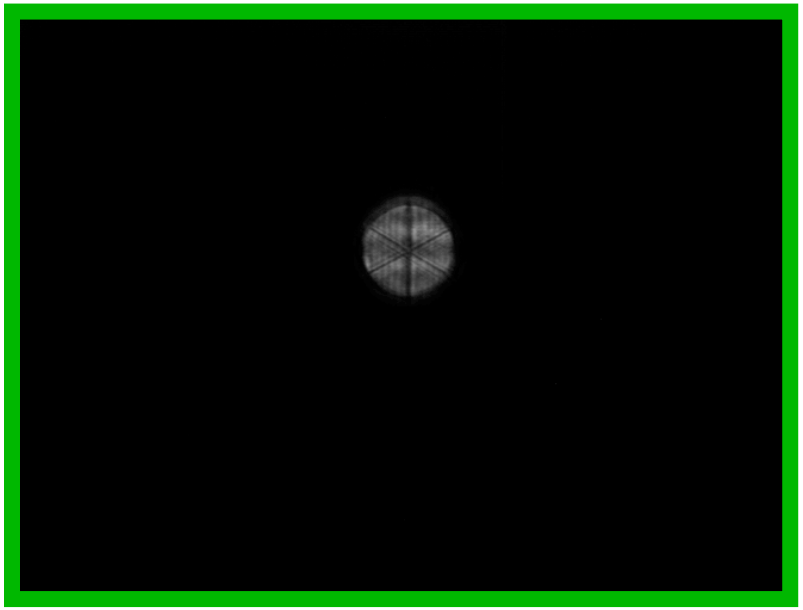
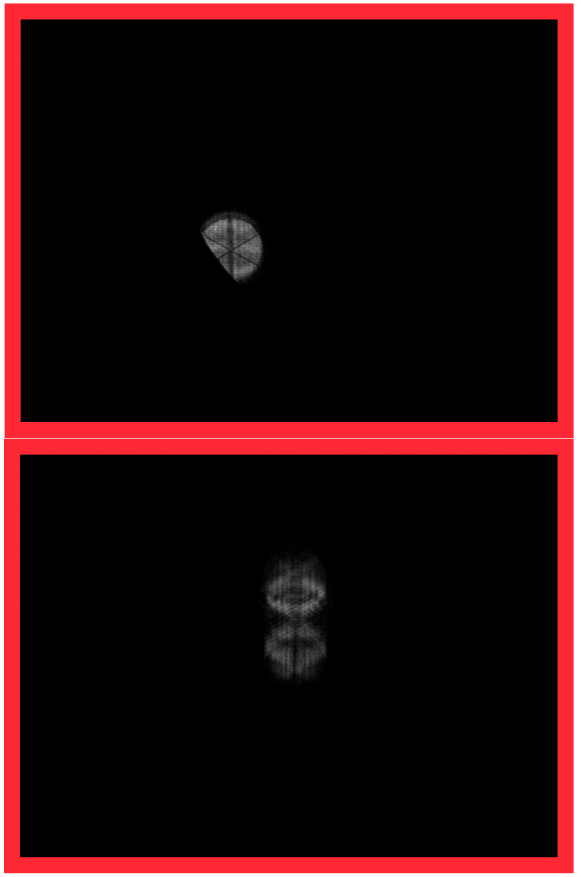
Normal



OFF-NORMAL



PROBLEM DEFINITION:

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GIVEN a measured image from the NIF automatic alignment system, DETECT whether or not it is Ågorma for further processing (e.g. centroiding), that is, ACCE a normal image, but REJECT an Ågff-normalÅh

OFF-NORMAL PRE-PROCESSOR

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- **Our solution to the NIF normal/off-normal "detection" problem is to develop a PRE-PROCESOR capable of performing the detection with the following specifications:**

  - **Fast:** **< 1 sec CPU time**
  - **Simple:** **must not use the 2D image, but transform it to a 1D domain (if possible)**
  - **Reliable:** **meet the Prob_miss specs (< 1%)**
  - **Robust:** **must be able to handle "all" possible off-normals**
  - **Smart:** **must use all available a-priori information**
  - **Flexible:** **must be able to add/subtract new algorithms easily**

PRE-PROCESSOR:

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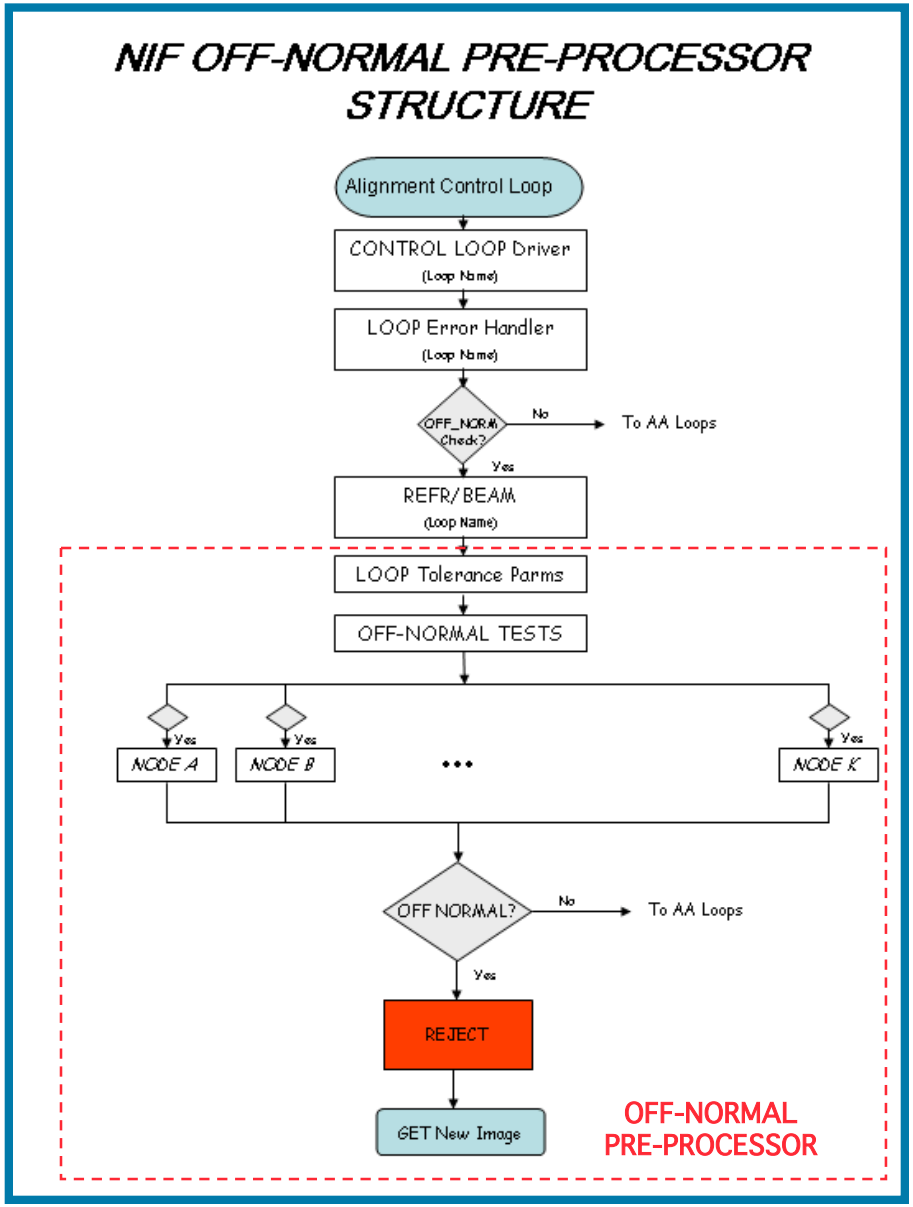

The Pre-processor algorithms are simple:

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- Full-Width Half Maximum (FWHM): estimates both row and column means producing 1D sequences, find the peak, cuts out section containing structure, extracts FWHM (50% peak), checks against ideal tolerances
- Skewness: uses extracted FWHM structure and estimates statistical symmetry (ideal image symmetric, nominal close, off-normal NOT close)
- Histogram: estimates 1D intensity histogram to "classify" images as all-black, gray, all-white as well as used to estimate dim, bright images
- 1D Pre-Processing: efficiently estimate and remove "linear" (common) trends from 1D signals

IDEAL IMAGE EXAMPLE: Pinhole (Gaussian) Spot

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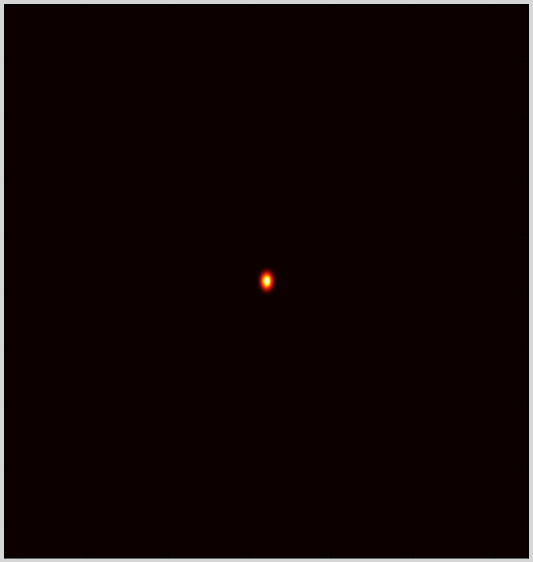

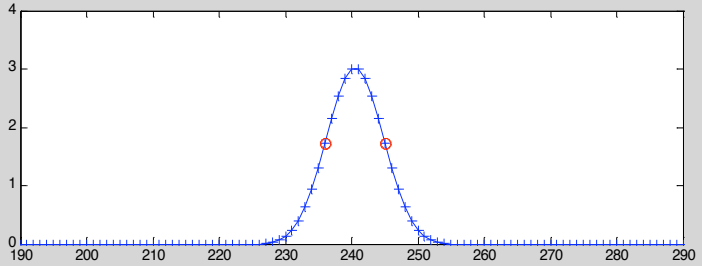

The raw image is transformed and preprocessed:

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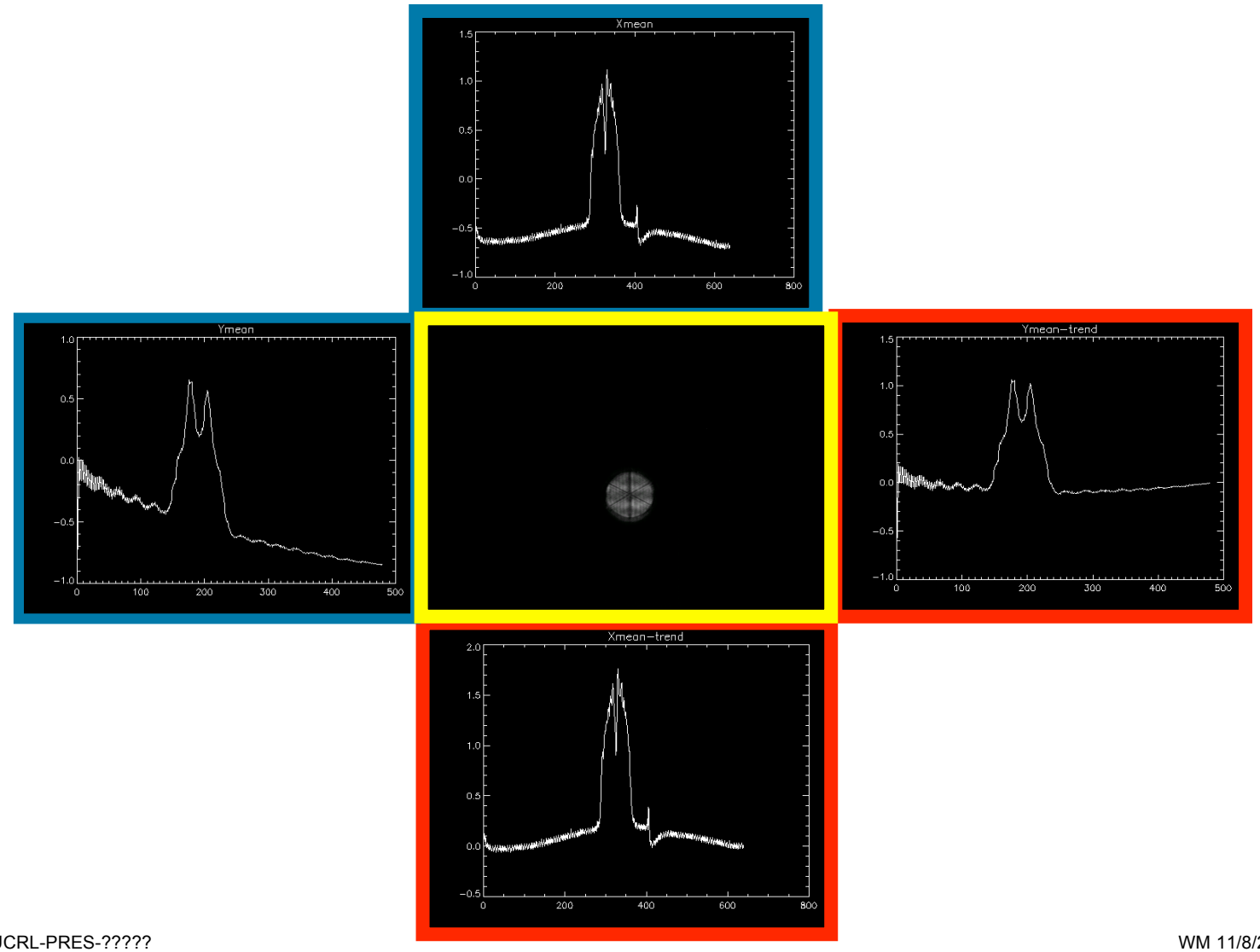

CASE STUDY: Back-Lit Corner Cube (FWHM/Skewness Tests)

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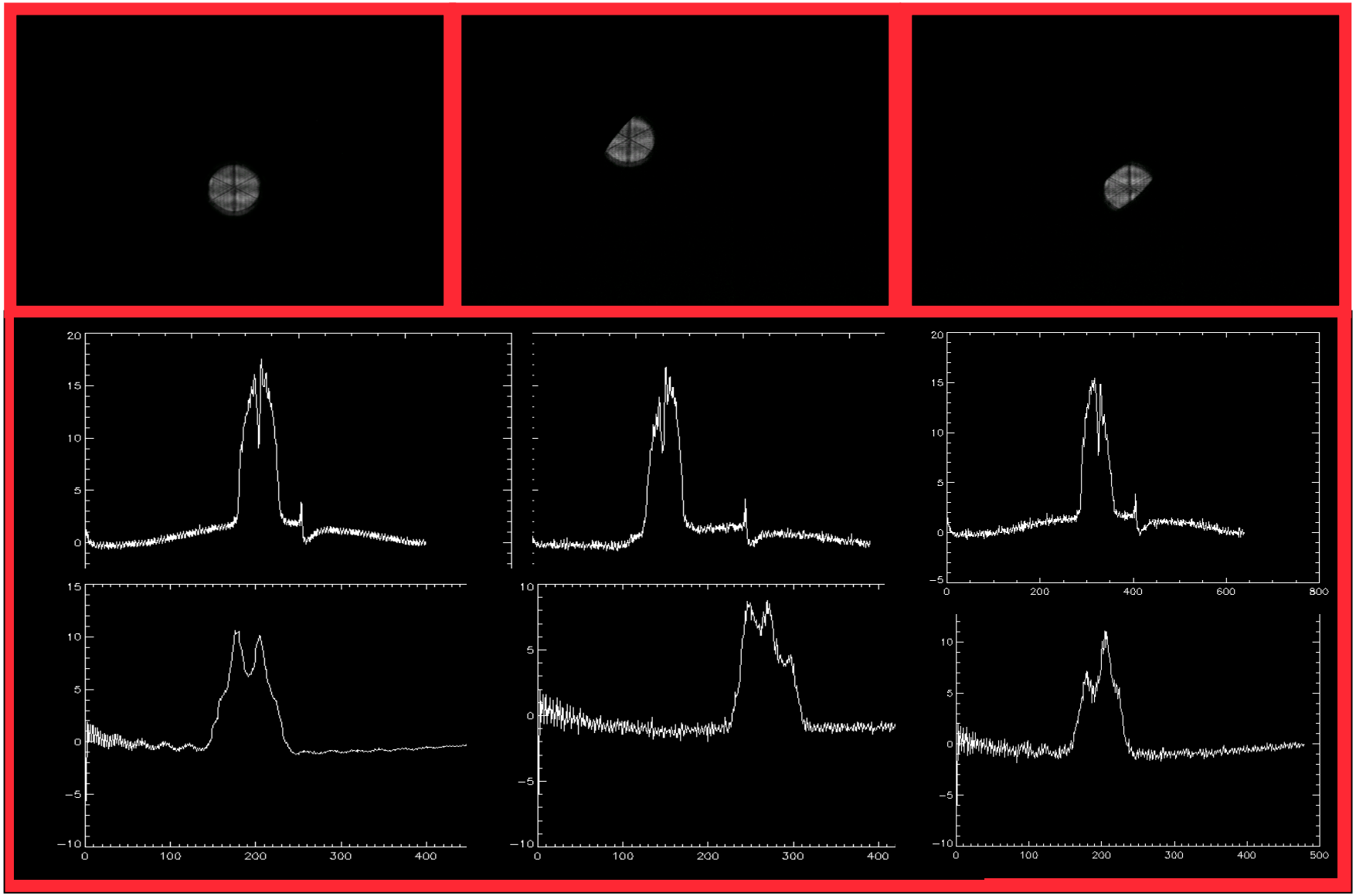

Summary

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- We have discussed the development of an OFF-NORMAL Preprocessor for NIF Automatic Alignment
- We have shown that it meets the design specifications (fast, simple, reliable, robust, smart and flexible)
- We have examined the overall structure, and
- We have demonstrated its performance on ideal, nominal and off-normal images